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Pengembangan Buku Ilmiah Populer Tentang Struktur Populasi Cempedak (*Artocarpus integer* (Thunb.) Merr) di Bantaran Sungai Barito Desa Sungai Gampa Kabupaten Barito Kuala

(Development of a Popular Scientific Book on the Population Structure of Cempedak (Artocarpus integer (Thunb.) Merr) Along the Barito Riverbank in Sungai Gampa Village, Barito Kuala Regency)

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ABSTRACT. Plant population structure refers to the existence of a plant group within a specific area. This study focuses on the Cempedak (*Artocarpus integer* (Thunb.) Merr) population along the Barito Riverbank in Sungai Gampa Village, Barito Kuala Regency, which possesses high potential as a local, context-based learning resource for students. This research aimed to (1) analyze the Cempedak population structure, (2) detail the development process, and (3) assess the validity and readability of a popular scientific book based on this structure, intended as supplementary material for a Plant Ecology course. The study employed a total exploration method along a defined section of the riverbank, combined with the Plomp development model for creating the book. The results revealed that the Cempedak population structure was imbalanced, characterized by a pot- or disrupted vase-shaped pyramid, indicating an uneven distribution across pre-reproductive, reproductive, and post-reproductive phases. Furthermore, the development process successfully followed the three phases of the Plomp model. Crucially, the final popular scientific book was assessed as highly valid by experts and demonstrated excellent readability among students, confirming its suitability as an instructional supplement.

INTRODUCTION

The development of relevant and contextual teaching materials is an essential need in modern biology education. This is particularly important in courses such as Plant Ecology, where understanding concepts like population structure heavily depends on students' ability to relate the material to real-life objects in their environment. Unfortunately, in practice, classroom instruction often still relies on generic teaching materials that do not reflect local representations, thus creating a gap between theoretical knowledge and students' learning realities.

The gap between the expectation of contextual learning and the actual limitation of locally-based teaching materials has been identified by various studies. One of the main challenges in teaching population concepts is the lack of learning resources that provide specific examples of local vegetation [1]. Teaching materials based on local potential lead to low student engagement and difficulties in understanding the link between ecological concepts and the realities of the surrounding ecosystem [2]. Therefore, a tangible gap exists that demands an innovative solution through the development of contextualized teaching materials.

The urgency of this research stems from the need to provide teaching materials that leverage local potential to address these challenges. A Popular Scientific Book (Buku Ilmiah Populer/BIP) is a learning medium that delivers scientific information in a communicative, easily understandable style. BIPs can help students grasp complex material through a more flexible approach without compromising scientific accuracy. In this context, the cempedak plant (*Artocarpus integer* (Thunb.) Merr.) presents a highly promising subject for educational content, given its wide distribution in South Kalimantan and its considerable ecological, economic, and ethnobotanical value.

Field facts support this urgency. Preliminary observations in the Biology Education Study Program at FKIP Lambung Mangkurat University indicate that students struggle to comprehend the topic of population structure in the Plant Ecology course. This difficulty is attributed to the lack of locally-based teaching materials that can facilitate student understanding of plant population contexts in their surrounding environment. The Barito River,

particularly the Sungai Gampa Village area in Barito Kuala Regency, is a potential habitat with a plentiful cempedak population that has not yet been utilized as an official teaching resource.

Several previous studies have attempted to address the challenge of developing locally based teaching materials. Developed a popular scientific book based on mangrove biodiversity for teaching biodiversity topics in high school, showing significant improvements in concept comprehension [3]. Developed a locally based booklet as supplementary material for the Kingdom Animalia topic. Created a popular scientific book based on the population structure of *Areca catechu* in Banjar Regency. All of these studies emphasize the importance of local context in enhancing students' understanding of the subject matter [4]. However, none has specifically developed a BIP based on the population structure of *cempedak* along the Barito Riverbanks. No previous research has developed a Popular Scientific Book based on the population structure of *cempedak* along the Barito Riverbanks.

Based on the synthesis of various studies and literature reviews, this research offers novelty through the development of a Popular Scientific Book that: (1) is based on the study of *cempedak* population structure as a representation of South Kalimantan's local vegetation; (2) utilizes the ecological potential of the Barito Riverbanks as a real-world learning object; and (3) is developed using the Plomp model to ensure the product's validity, practicality, and effectiveness. Therefore, this study not only fills the void in locally-based learning resources but also contributes to pedagogical innovation in biology education.

RESEARCH METHOD

This study employed a research and development (R&D) approach using the Plomp development model, which consists of three main phases: (1) preliminary research, (2) prototyping phase, and (3) assessment phase. This model was chosen because it provides flexibility in product development based on user needs and ensures the validity, practicality, and effectiveness of the final product.

The research subjects consisted of three expert lecturers as validators from the Biology Education Study Program, Faculty of Teacher Training and Education (FKIP), Lambung Mangkurat University, and five students who had completed the Plant Ecology course with an A grade, serving as the readability test participants. The object of this research was a Popular Scientific Book (Buku Ilmiah Populer/BIP) on the population structure of cempedak, developed based on ecological studies conducted along the Barito Riverbanks, particularly in Sungai Gampa Village, Barito Kuala Regency.

This research was carried out in two locations: (1) the Barito Riverbanks area, for field data collection on the cempedak population; and (2) the Biology Education Study Program, FKIP Lambung Mangkurat University, for product development and validation. The research period lasted six months, from January to June 2025, encompassing preparation, data collection, analysis, compilation, and product testing stages.

The research instruments included environmental measurement tools (thermometer, hygrometer, lux meter, altimeter, soil tester), data recording tools (stationery, GPS, camera, measuring tape), and data collection instruments such as needs analysis questionnaires, morphological description forms, expert validation sheets, and readability test sheets. The development procedure began with a user needs analysis through student surveys and a review of the Plant Ecology course syllabus (RPS). Field data were then collected to describe the population structure of cempedak based on growth phases (pre-reproductive, reproductive, and post-reproductive) and habitat environmental analysis.

During the prototyping phase, the BIP was compiled according to the popular scientific book structure recommended by LIPI, which includes components such as title, foreword, introduction, table of contents, content explanation, glossary, and synopsis. The prototype was validated by three expert validators who assessed the content, presentation, language, and graphic aspects. Revisions were made based on the feedback before conducting the readability test with five students who had taken the relevant course.

Data analysis was conducted descriptively. The population structure data were analyzed using the IUCN (2014) guidelines, with the following categories: not critical (>25 mature individuals/km²), critical (5–25 mature individuals/km²), and endangered (<5 mature individuals/km²). Validity data were analyzed using the average score from three validators with the following categories: very valid (3.26–4.00), valid (2.51–<3.26), less valid (1.76–<2.51), and not valid (1.00–<1.76). Readability data were analyzed using the readability percentage formula:

$$PK = \frac{Total\ Score\ Obtained}{Total\ Maximum\ Score} \times 100\%$$

The interpretation criteria for readability were categorized as follows: very good (>80%), good (70–<80%), fairly good (60–<70%), poor (50–<60%), and very poor (<50%). The results from all these stages served as the basis for the refinement of the BIP before limited publication and dissemination.

RESULTS AND DISCUSSION

1. Population Structure of Cempedak (*Artocarpus integer* (Thunb.) Merr.) At The Barito Riverbanks, Sungai Gampa Village, Barito Kuala Regency

This study identified the population structure of Cempedak trees along the Barito Riverbanks in Sungai Gampa Village. The data collection employed the total exploration method (census). This method involved a systematic sweep of the designated research area (3.038 km length x 50 m width), where every individual plant encountered was recorded and categorized based on its growth phase without using sampling plots, ensuring a complete inventory of the existing population [5].

Morphological observations indicated significant structural variation between phases. The pre-reproductive phase was characterized by trees less than 1.41 meters in height, with trunk diameters ranging from 1.43 to 7 cm, and light greenish-brown bark; these individuals had not yet produced flowers or fruits. The reproductive phase included trees taller than 5.1 meters, with trunk diameters between 17.2 and 29.9 cm, exhibiting active reproductive structures (flowers and fruits) and fruit scars on the stems. In the post-reproductive phase, trees were generally taller than 5.54 meters, with darkened, dry bark, and exhibited signs of physiological aging and structural deterioration.

Table 1. Characteristics of Cempedak Population Structure at the Barito Riverbanks, Sungai Gampa Village, Barito Kuala Regency

Parameter	Pre-reproductive Phase	Reproductive Phase	Post-reproductive Phase
Height (m)	< 1.41 m	> 5.1 m	> 5.54 m
Trunk Diameter	1.43 – 7 cm	17.2 – 29.9 cm	15.28 – 62.1 cm
First Branch Height	97 – 136 cm	71 – 131 cm	171 cm
Bark Color	Light greenish brown	Dark brown	Blackish brown
Other Characteristics	No flowers or fruits, branches have fine hairs	Has flowered and fruited, fruit scars visible on the stem	No longer flowering or fruiting, mostly dry leaves, the main trunk has been cut or broken

Population structure calculations within the 0.152 km² observation area showed that the reproductive phase dominated with a density of 203.94 individuals/km², followed by the pre-reproductive phase at 151.31 individuals/km², and the post-reproductive phase at 46.05 individuals/km². This population distribution forms a vase-shaped pyramid, representing a population structure in which the number of young individuals is fewer than that of mature individuals [6].

Table 2. Population Structure of Cempedak Plants at the Barito Riverbanks, Sungai Gampa Village, Barito Kuala Regency

No	Growth Phase	Total Individuals (Ind/15.20 Ha)	Individuals per Hectare (Ind/Ha)	Individuals per Square Kilometer (Ind/km²)
1	Pre-reproductive	23	1.51	151.31
2	Reproductive	31	2.03	203.94
3	Post-reproductive	7	0.46	46.05

The calculation of the population structure of *Cempedak* at the Barito Riverbanks, Sungai Gampa Village, Barito Kuala Regency (within 0.152 km²) based on Odum's criteria is categorized as a vase-shaped pyramid, which is characterized by a lower number of young individuals compared to older individuals. The population structure pyramid of *Cempedak* in this location is presented in Figure 1.

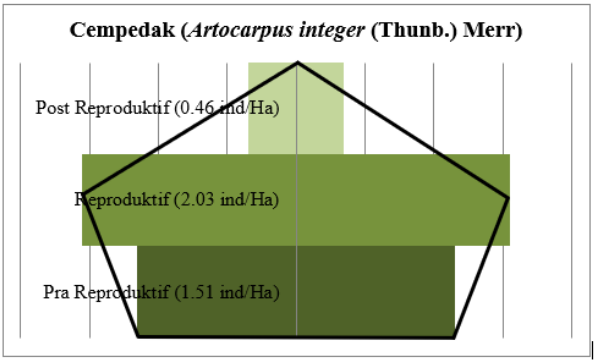

Figure 1. Population Structure Pyramid of Cempedak Plants

Environmental Suitability vs. Population Structure The analysis of abiotic factors (Table 3) shows that the environment is actually highly suitable for Cempedak growth. Light intensity (10,940–>20,000 lux), soil moisture (90–100%), and soil pH (5.6–6.0) are within the optimal range for *Artocarpus* species. This leads to a critical ecological conclusion: The "vase-shaped" structure is not caused by environmental limitations (abiotic factors), as the habitat is ideal. Instead, it is primarily driven by anthropogenic factors (human intervention) that disrupt the natural regeneration cycle through fruit exploitation and lack of cultivation efforts.

Table 3. Environmental Parameter Measurements at the Barito Riverbanks, Sungai Gampa Village, Barito Kuala Regency

A. Abiotic Factors

No	Environmental Parameter	Observed Range	Reference Range
1	Light Intensity (lux)	10,940 – >20,000	100 – 10,000
2	Wind Speed (km/h)	0.0 – 1.8	0.5 – 2.0
3	Soil pH	5.6 – 6.0	5.5 – 6.8
4	Soil Moisture (%)	90 – 100	25 – 40
5	Air Humidity (%)	54.4 – 78.2	75 – 95
6	Air Temperature (°C)	29 – 34	27 – 32
7	Water Temperature (°C)	27 – 30	25 – 30
8	Water Clarity (cm)	50 – 62	50 – 100
9	Water pH	6.1 – 7.0	5.5 – 7.5

B. Biotic Factors

1. One part of the *Cempedak* plant, namely the fruit, is harvested for consumption and sale, but the seeds are rarely replanted.
2. Residents of Sungai Gampa Village use *Cempedak* wood for firewood, contributing to a decrease in the tree population over time.

There is currently no specific regulation regarding logging or conservation of this species. Given that the vase-shaped structure implies a threat to future regeneration, a community-based conservation strategy is urgently needed, focusing on seed replanting programs to restore the base of the population pyramid.

2. Development Process of the Popular Scientific Book

The Popular Scientific Book (PSB) on the population structure of *Cempedak* was a development model, which consists of three phases [7]:

(1) Preliminary Research, involving literature review, needs analysis, and field study;

(2) Prototyping Phase, covering content development, layout design, visual illustration, and expert validation;

(3) Assessment Phase, comprising a readability test and limited publication via social media.

The resulting PSB has met high indicators of validity and readability. Validation by three expert lecturers yielded an average score of 3.35 (categorized as very valid), while a readability test by five students resulted in a score of 89% (categorized as excellent). The book integrates actual ecological data with communicative narrative and visual approaches, making it an appropriate learning resource to support contextual learning in the Plant Ecology course.

2.1 Preliminary Research Phase

a. Population Structure Study

The initial study involved the collection and analysis of *Artocarpus integer* (Thunb.) Merr. population data along the Barito Riverbanks in Sungai Gampa Village. The survey was conducted using a total roaming method, resulting in a density of 1.51 individuals/ha (pre-reproductive phase), 2.03 individuals/ha (reproductive), and 0.46 individuals/ha (post-reproductive). This distribution forms a vase-shaped pyramid, indicating fewer young individuals than older ones. These data served as the foundation for material development in the PSB.

b. Curriculum Review of the Plant Ecology Course (RPS)

An analysis of the Plant Ecology course syllabus (RPS) from the 2020 Biology Education Curriculum indicated a need for material on population structure to achieve the course learning outcomes. The targeted sub-CPMK includes students' ability to analyze the relationship between plants and their environment, population principles, and growth. Accordingly, the PSB was structured to include topics such as an overview of *Cempedak*, ecosystem characteristics of the Barito River and Sungai Gampa, population structure concepts, benefits of *Cempedak*, and conservation efforts.

c. User Survey

A survey was conducted using Google Forms involving course instructors and six students from different cohorts. All lecturers (100%) agreed on the need for a PSB to support lectures and confirmed the absence of a specific PSB on local plants. Meanwhile, most students had never used a PSB before but expressed high interest in local, communicative, and easily understandable learning resources. All respondents supported the development of a PSB based on local potential.

2.2 Prototyping Phase

This phase involved compiling the PSB content and design based on findings from the preliminary phase. The structure followed the Indonesian Institute of Sciences. Format, including: Title, Copyright, Foreword, Preface, Table of Contents, List of Figures, List of Tables, Main Content (population structure and ecology of *Cempedak*), Conclusion, References, Author Biography, and Synopsis. Visual components include images and scientific data from the research [8].

The content design featured educational elements such as: *an introduction to Cempedak morphology, a description of the riverbank ecosystem, a population structure pyramid, and an* analysis of abiotic and biotic factors. Conservation narratives based on local community interviews were also included. The visual layout was made engaging and informative, combining scientific data with a reader-friendly presentation for non-academic audiences.

Validation by three expert lecturers yielded a score of 3.35 (very valid), while the readability test achieved a score of 93% (excellent), indicating that the PSB meets both scientific and general comprehension standards.

2.3 Assessment Phase

After the PSB was validated and deemed appropriate by experts and students, a limited digital distribution was implemented. The publication took the form of a flipbook link shared via Instagram: https://www.instagram.com/norhafizah28. Within 24 hours, the PSB received 265 views with positive engagement metrics: 94.6% from followers and 5.4% from non-followers, resulting in 48 likes and 36 flipbook link clicks.

Although a comprehensive summative evaluation has not been conducted, the initial feedback suggests that the audience well received the PSB. This indicates the potential for sustainability in locally contextualized learning material development and highlights the importance of integrating digital media to disseminate learning resources.

3. Feasibility of the Popular Scientific Book

3.1 Validity of the Popular Scientific Book

The PSB on the population structure of *Artocarpus integer* (Thunb.) Merr. was developed to support the learning outcomes of the Plant Ecology course in the 2020 curriculum. Its validity was assessed by three expert lecturers across several aspects: coherence, readability, vocabulary usage, sentence structure, scientific writing format, and pedagogical approach.

The validation results showed scores ranging from 3 to 4 in all aspects, with an average score of 3.35, categorized as very valid. Revisions were made based on feedback, including adding transition sentences, adjusting format and content, and enhancing visual quality.

4. Research Findings and Discussion

4.1 Population Structure of Cempedak (Artocarpus integer (Thunb.) Merr.)

The study revealed that the population structure of *Cempedak* along the Barito Riverbanks in Sungai Gampa Village formed a vase-shaped pyramid, with a dominant number of individuals in the reproductive phase compared to the pre-reproductive and post-reproductive phases. This distribution is influenced by both natural and anthropogenic factors, including local traditions of planting but not intensively harvesting *Cempedak* trees. Environmental factors such as light, soil moisture, pH, temperature, and wind speed were found to be within the optimal range for *Cempedak* growth. According to IUCN criteria, the *Cempedak* population is classified as Least Concern (LC) due to the number of mature individuals exceeding the critical threshold.

Three main factors influence plant life: Climatic factors, such as light, temperature, water, wind, and their seasonal variations; edaphic factors, which include soil moisture, aeration, pH, slope gradient, and mineral content; and biotic factors, involving plants and animals that affect growth and limit plant distribution [9].

4.2 Development of the Popular Scientific Book

The PSB was developed using the Plomp model, comprising three phases: preliminary analysis, prototype development, and assessment. The initial stage involved population structure analysis, curriculum relevance review, and user needs surveys. During the prototyping phase, the content was structured using a popular scientific format, and the book design adhered to defined standards. Validity testing was conducted by three Biology Education lecturers at FKIP ULM, and readability was tested by five students who had completed the Plant Ecology course. The final product was disseminated in a limited scope via social media.

Studies using the Plomp model for teaching material development include: [10] whose developed material was found to be valid, practical, and effective, [11] who developed a popular scientific book with a “very valid” result, and [12] who developed a flipbook-based e-module.

4.3 Book Validity

Validity testing evaluated content feasibility, readability, and presentation appropriateness. Three validators assessed nine main aspects, including coherence, readability, vocabulary, active/passive sentence usage, format, writing method, application, definitions, and writing style. The average validity score reached 3.35 (very valid). Revisions included adding transition sentences, improving visuals, and refining content structure.

Analogies in writing popular scientific books play a key role in bridging readers’ understanding of complex concepts by linking them to familiar everyday experiences [13].

4.4 Readability of the Popular Scientific Book

Readability testing yielded a score of 89%, indicating excellent clarity in content structure, language use, and visual presentation. Students found the book helpful in understanding population structure material and appreciated its engaging and scientifically sound presentation of local potential. The simple, illustrative, and relevant content made the book an effective learning medium.

Readability testing allows authors to assess sentence structure clarity, word choice, and information flow. This is crucial to ensure that the content is not only informative but also communicative and easily understood by target readers, especially in popular scientific publications [14].

CONCLUSION

Based on the results of the development research of the Popular Scientific Book (Buku Ilmiah Populer/BIP) on the population structure of *Cempedak* (*Artocarpus integer* (Thunb.) Merr.) along the Barito Riverbanks in Sungai Gampa Village, Barito Kuala Regency, as a supplementary teaching material for the Plant Ecology course, the following conclusions can be drawn:

1. The development process of the BIP referred to the Plomp development model, which consists of three phases: (1) Preliminary research, including a study of the *Cempedak* population structure, analysis of the 2020 curriculum course syllabus (RPS) for Plant Ecology, and a needs survey of students; (2) Prototyping phase, involving content preparation, prototype design, and expert product validation; (3) Assessment phase, involving limited dissemination via social media as the initial stage of product distribution.
2. The ecological study showed that the *Cempedak* population structure at the research site falls into the non-critical category based on IUCN (2014) criteria, with population densities of 151.31 individuals/km² in the pre-reproductive phase, 203.94 individuals/km² in the reproductive phase, and 46.05 individuals/km² in the post-reproductive phase. The population structure followed a vase-shaped pyramid pattern, indicating a lower number of young individuals compared to older ones.

3. The validation results showed that the developed BIP obtained an average score of 3.35, categorized as very valid. The readability test with students yielded a score of 89%, classified as excellent. These results indicate that the BIP is feasible as a contextual learning resource in the Plant Ecology course.

Teaching material development contributes significantly to the future of biology education, particularly in integrating local potential into ecosystem-based learning. By utilizing local plants as study objects, students are expected to gain a deeper understanding of ecological principles and their relation to biodiversity conservation. Moreover, the development of this BIP encourages pedagogical innovation that is adaptive to learning needs, grounded in local wisdom and ecological context.

This study provides room for further development. Therefore, several suggestions are proposed for future researchers:

1. Subsequent studies are advised to avoid the use of excessive narrative expressions or figurative language, as scientific popular books in the natural sciences should convey information objectively, concretely, and based on data.
2. The research area should be expanded beyond Sungai Gampa Village to include the entire stretch of the Barito River, in order to obtain more representative data on the distribution and dynamics of the *Cempedak* population.
3. It is necessary to conduct an effectiveness test on the developed BIP to determine the extent to which it impacts students' understanding and learning interest empirically.
4. Future research should also include summative product evaluation after dissemination to assess long-term impacts and the effectiveness of the product implementation in broader learning contexts.
5. Considering that the distribution pattern of *Cempedak* along the Barito Riverbanks has not yet been fully explored, further studies are needed to examine its spatial and ecological distribution, thereby enriching local biodiversity and conservation studies.

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